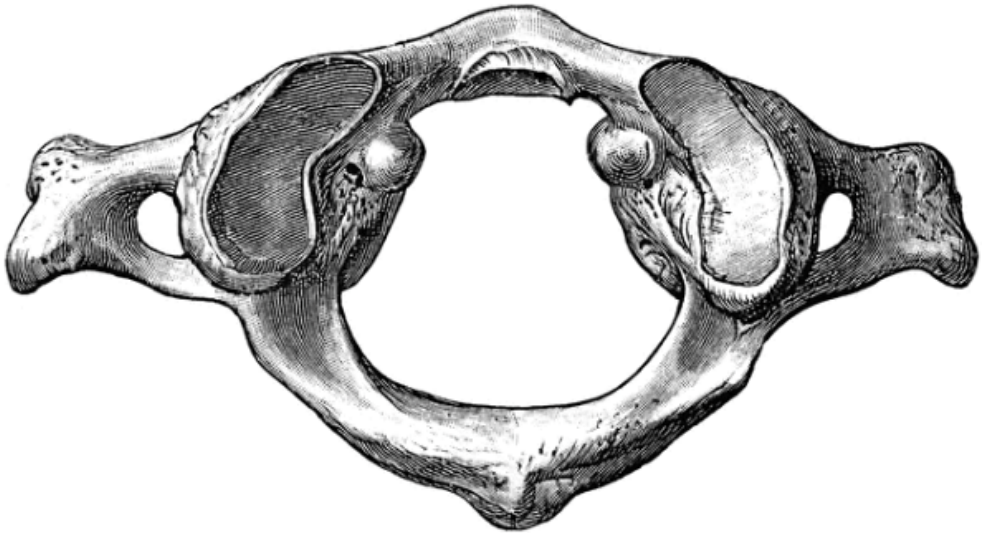
CURRENT EVIDENCE ON THE EFFECTS OF ATLAS VERTEBRA CORRECTION IN PATIENTS WITH AN ATLAS MISALIGNMENT- A LITERATURE REVIEW



Student: Anna Wieneke

Student number: 328208

Supervisor: Anne-Griet Brader

Date: June 2018

Hanzehogeschool Groningen
University of Applied Sciences
Academie voor Gezondheidsstudies

HANZEHOGESCHOOL GRONINGEN INTERNATIONAL PROGRAM OF PHYSIOTHERAPY

Preface

The upper cervical spine is a remarkable complex segment, that allows the widest range of motion relative to the rest of the spine. Since my current workplace is specialized in atlas vertebra correction, it raises my interest to evaluate the current literature about the effects of different atlas vertebra corrections. When the atlas becomes subjected to stress or trauma, it can lead to a ´positional fault´ in relation to the skull or other cervical vertebrae. This review is based on a physiotherapeutic approach. However, as most scientific literature focuses on chiropractic intervention, the topic will therefore be analysed from that interdisciplinary perspective. Main emphasis is placed on the primary outcomes such as headache, migraine, tinnitus and high blood pressure which will be explained in this literature review.

I would like to use the opportunity to appreciate the people supporting me during my graduation assignment. I thank all who in one way or another contributed in the completion of this bachelor thesis. At first, my special thanks to my supervisor Anne-Griet Brader, who encouraged and directed me throughout the process. Additionally, I want to thank my boss Stefan Datt who supported me well during the graduation assignment and equipped me with relevant literature. Furthermore, I am thankful to my fellow students and friends Clara Mönch, Annahita Shirazi, Felicitas Britschgi and Erwan Vaujani by supporting me in giving feedback and proofreading this literature review.

Anna Wieneke

Abstract

Introduction: An increasing number of people are suffering from headaches, migraine, tinnitus and high blood pressure in today's population. These symptoms may be caused by an atlas misalignment. Nowadays, many different approaches to realign the atlas vertebra exits in a multidisciplinary context.

Aim: The aim of this study is to review the current evidence on the effects of atlas vertebra correction in a physiotherapeutic context.

Method: A comprehensive literature search was conducted on the databases PubMed, PEDro, Cochrane, Embase and Google Scholar. Additional sources were taken from atlas vertebra specialists. The quality of the studies was evaluated by different quality assessment forms best suited to the study design.

Result: An amount of eight articles were included, amongst which are 2 pilot studies, 1 retrospective studies, 2 cohort studies and 3 case studies. These studies include six different approaches to realign the atlas, of which two can be applied by physiotherapists (AtlasPROfilax, ATLANTOtec) and four by chiropractors (NUCCA, IUCCA, KCUCS and Gonstead).

Conclusion: From the current state of evidence, there is pronounced lack of evidence on whether an atlas vertebra correction can be beneficial to perform in physiotherapeutic departments. In a chiropractic context, approaches to correct the atlas vertebra are used more frequently. However, further scientific literature is required to evaluate the effects on atlas vertebra correction on a more scientific level. Future research implications are discussed.

*Key*words: atlas misalignment; atlas vertebra correction; manipulation; therapy; physiotherapy and effects

Introduction

The cervical spine is an incredibly important and yet very fragile region, connecting the structures of the central nervous system to the rest of the body. When the atlas becomes misaligned it can lead to pain and poor health (Dr. Gott, M.D. 2017). Already muscular imbalances can lead to minor positional changes of the atlas that shifts the sagittal axis off centre (Dr. Tempelhof, S. 2017). The study by Scheer et al. (2013), reports that cervical spine ´deformity´ can be either primary (congenital) or secondary, caused by iatrogenic diseases like ankylosis spondylitis, a pathology characterized by bone ossifications. Injuries between the upper cervical spine and the occiput can influence the brain, brainstem and spinal cord and may therefore lead to headache, fatigue, vertigo, poor concentration, hypertonia and irritability (Magee, D. J. 2006). Additionally, the book by Göring, H. (2012) reports, that an atlas vertebra is hard to dislocate and can therefore only ´sub-luxate´ to a tenth of millimetre. It is known that in today's population the number of headache, migraine, tinnitus and high blood pressure raises steady. In the year 2015, globally 1.13 billion people living with high blood pressure (Senthilingam, M. 20016). The world health organization (WHO) has estimated that globally about 50% among adults between 18-65 years have experiences headache and 30% of the population reported to suffer from migraine (WHO, 2016). The study by Davis & Refaie (2000) reported that approximately 10 to 20% of the population have experienced some form of tinnitus.

The atlas (C1) is the uppermost cervical vertebra placed directly beneath the skull. The human head weighs five to six kilograms on average, that balance on the atlas vertebrae, with just 1,5-2cm² contact surface to the skull (Dr. Tempelhof, S. 2017). The vertebral artery passes through the transverse process of C1, which may restrict the blood circulation after injury. This blood restriction can lead to vertigo, nausea or tinnitus and in rare cases to a stroke or death (Magee, D. J. 2006). Looking at the nervous system, the trigeminus nerve is the fifth cranial nerve that regulates the jaw joint-, the masticatory-, mouth floor-, tongue-, jaw- and neck musculature. If the trigeminus nerve gets irritated through malposition of C1, certain symptoms may arise: headache, vertigo, equilibrium complaints, tinnitus, joint pain, numbness, difficulties in swallowing, jaw joint problems, teeth crunch (Bruximus), shoulder-neck complaints and hypertonus (Dr. Tempelhof, S. 2017). Research by Solow, B. (1998) has shown that individuals at the age between seven and thirteen suffering from tooth crowding have a significant higher chance to develop a forward head posture (n = 96), which may be an influencing the development of an atlas vertebra misalignment. Furthermore, the study by Knutson, G. A. (2005) reported that suprapelvic muscle hypertension may be caused of upper cervical joint dysfunction, that could investigate a leg length discrepancy.

Looking back to the past, the atlas vertebra has always played an important role in medicine. The so called "Hole-in-one" procedure, introduced by James Palmer since the mid 1930ies, has been widely used in practice. The name is originally from Golf sports, which means that the therapist should bring the best possible success within one blow. It is the first established therapeutic intervention that corrects the atlas vertebra (Keating, J. P. 2005). In the book of Göring, H. (2012), doctor Arlen is mentioned as having conducted research to evaluate the atlas vertebra position on radiographic pictures, which resulted in the finding that on 2250 X-rays images, an amount of 81.6% of the population had a left atlas vertebra shift (Göring, H. 2012).

Nowadays, several physiotherapeutic institutions offer an atlas vertebra correction and advertise with good results, albeit there is insufficient evidence to assure such results. However, there is more evidence for chiropractic approaches, which are mainly using

manipulative instead of mobilisation interventions to realign the first cervical vertebra see explanation in appendix I. The cervical spine manipulation is a commonly employed intervention, although it is still very controversial and can bring along different issues as a side effect. The literature review by Emilio et al., (2012) evaluated a total amount of 134 participants who received cervical spine manipulation, of which n = 7 died, mainly caused by arterial dissection. Therefore, cervical manipulation needs to be regarded with caution, especially with respect to the rate of force application, the location in range of movement, the direction of force, the target of force, the structural movement and the patient's position. Hurwitz et al., (2002) reported evidence on 336 participants showing that manipulation of the cervical spine on patients with neck pain is as efficient as neck mobilization in regard to pain intensity or disability. In physiotherapeutic facilities, manual therapy on the cervical spine is frequently applied. However, physiotherapeutic literature that put the main emphasis on the atlas vertebra is rarely found. Thus, a multidisciplinary view in terms of the atlas vertebra position and its therapy is at interest.

The aim of this review is therefore to evaluate the effects on different approaches to realign the atlas vertebra in patients with an atlas misalignment. Primary attention was set towards headache, migraine, tinnitus high blood pressure and leg length discrepancy, since these are the most common symptoms in the included studies. Further background information will be explained in the appendix I to instil different used procedures to realign the first cervical vertebra and the underlying mechanisms.

Methods

Search Strategy

From February to April 2018 the following electronic databases were searched: PubMed, Physiotherapy Evidence Database (PEDro), Cochrane, Embase and Google Scholar. Randomized controlled trials, pilot studies, retrospective practice-based studies, and case reports were included in this literature review. The following Medical Subject Heading (MeSh) terms were used: ´Cervical Atlas´ AND ´Bone Malalignment´ OR ´Disposition´ OR ´Misalignment´ AND ´physical therapy´ OR ´physiotherapy´ OR ´therapy´ AND ´signs and symptoms´. The keywords, which were used are: cervical spine, upper cervical spine, atlas dislocation, atlas vertebra malalignment, atlas vertebra misalignment, atlas subluxation, atlas therapy, atlas correction, atlas vertebra correction, manipulation, treatment, therapy, physiotherapy and effects. The different search terms where combined with the Boolean Operator AND and OR in various combinations (see appendix III). Primarily, the references were selected on the basis of their title, followed by the abstract, and furthermore by a more detailed reading through the introduction and the discussion section. Additionally, the sources of retrieved reviews, reports and information from an atlas vertebra therapist were taken to receive more conclusive physiotherapeutic data. Furthermore, a separate search about sustained natural apophyseal glides (SNAG´s) and movement with mobilization (MWM) was performed to collect more data. These manual therapy techniques were taught in classes prior to the writing of this paper. However, there were no further studies to be found during the present literature search.

In- and Exclusion Criteria

Types of studies

The inclusion criteria comprise controlled trials with or without randomization, pilot studies, retrospective practice-based studies, cohort studies and case reports. There was no time restriction settled. The included language was English and German. Expected outcomes should contain information about the effects of atlas vertebrae correction involving different procedure. The exclusion criteria encompass studies with either no abstract or no full text availability. Additionally, evidence level V that involves expert opinion were excluded, due to lack of confounding factors that lead to bias by the authors experiences and/or opinions (Burns, P et al., 2011).

Study Population

The study population consists of both male and female older than ten years with or without traumatic event. According to the world health organization (WHO), the age classification from 10 to 19 years refers to adolescents. Additionally, included subjects that suffer from an atlas malalignment and received an atlas vertebrae realignment approach.

Types of intervention

Interventions include physical therapy and medical approaches to expand the scope. Studies that investigate a surgery or fractures on the atlas vertebra were abandoned to keep the main focus on manual therapy instead of post-surgical interventions, which would deviate too far from the original purpose. To receive the maximum of evidence, all interventions were included.

Outcome Measures

Primary, the focus is set on the effects on atlas vertebra correction, measured by different approaches. Parameters like symptoms, clinimetrics and pathologies were included to evaluate the results.

Data extraction and assessment

The literature search was conducted by a single independent assessor. Firstly, an expanded screening was selected via the title, followed by the abstract. The remaining articles were then scanned through the introduction and discussion section followed by reading of the full text if available. Additionally, a supplementary search was performed by perusing the sources of topic related literature reviews.

Quality Assessment

The quality analysis for RCT´s and Pilot studies was determined by the PEDro scale, the cohort studies were evaluated by the ´Newcastle-Ottawa Scale´ and the case studies were assessed by the ´CARE-Statement Scale´.

Newcastle-Ottawa Assessment Form

The quality of included cohort studies was assessed by the ´Newcastle-Ottawa Assessment Form´ (Wells et al., 2009). This form consists of a selection part with four numbered items, a comparability part with one numbered item and the outcome part having three numbered items. The result is evaluated by stars (*) which denote, that more stars indicate a higher quality. A good quality predicates an amount of three or four stars in the selection domain, one or two stars in compatibility domain, and two or three starts in the outcome domain. A fair quality was given with two starts in the selection domain, one or two starts in the domain of comparability, and two or three stars in the outcome domain. The result of zero or one star in the selection domain, zero stars in comparability domain, or zero or one stars in the domain of outcomes count as poor quality.

PEDro scale

The PEDro scale is a commonly used tool for quality testing of randomised controlled trials (RCT) and can be used additionally to evaluate the quality of pilot studies. The scale has eleven items. The first item analyses the generalizability of the study and is not counted in the final score. Item two to nine measure the internal validity and the results, item ten and eleven are based on the amount of statistically information (Physiotherapy Evidence Database [Online], 1999). The answers are given in a binary form with “yes” or “no” and a total score amounts to 10/10. A score of five or more points indicates a moderate to high evidence (Moseley, A.M., 2002).

Care Statement Scale

The care guideline was designed to increase the accuracy, transparency and usefulness of case reports. It was developed by an international group of experts and has been used by medical journals and is translated into several languages. The checklist contains thirteen different items including seventeen different sub-items, that are structured by the composition of the case study. A total amount of 30/30 would indicate a comprehensive case study indicating high quality (Gagnier, J.J. et al., 2013).

Results

Search results

The initial search resulted in 426 hits using five different databases and recommendation of an atlas vertebra therapist. After screening the articles by the title, an amount of 372 articles did not meet the inclusion criteria and only 54 studies remained. By reading the abstract a total number of 31 articles were selected, while a total of 13 abstracts were not available. Of the 31 selected articles, full text was not available (n = 7), an amount of 3 articles included infants or a population younger than ten years, and others applied a surgery to the cervical spine (n = 9) or did not applied atlas vertebral correction (n = 4). Studies that were selected by abstract were pilot studies (n = 3), a retrospective study (n = 1), cohort studies (n = 3), case studies (n = 3), expert opinion that was only later recognised as such and then excluded (n = 1), books) (n = 3) and one journal (n = 1).
A supplementary search to extend the scope was done by checking the sources of topic related literature reviews, which resulted at first in 6 articles. From these six studies, three articles met the inclusion criteria and thus were included to read fully. These included a retrospective based practice study (Palmer & Dickholtz, 2009) and two case reports (Kessinger & Moe, 2015 and Demetrious J., 2007).

Information from full text reading

After full text reading, the literature by Kaute B.B., (1998) was excluded, as it turned out that this literature is an expert opinion. Interestingly, it was not stated in the title nor in the abstract. The case report by Demetrious J., (2007) was excluded after full text reading, due to the lack of clear information about the cervical spine correction, for example whether it was applied on the C1 or on other cervical vertebrae. To sum up, eight articles meet the inclusion criteria and were therefore included in this literature review (Alcantara et al., 2002; Bakris et al., 2007; Elster E.L., 2004; Kessinger & Moe, 2015; Lerro A., 2010; Palmer & Dickholtz, 2009; Voigts FM., 2013; Woodfield III et al., 2015).

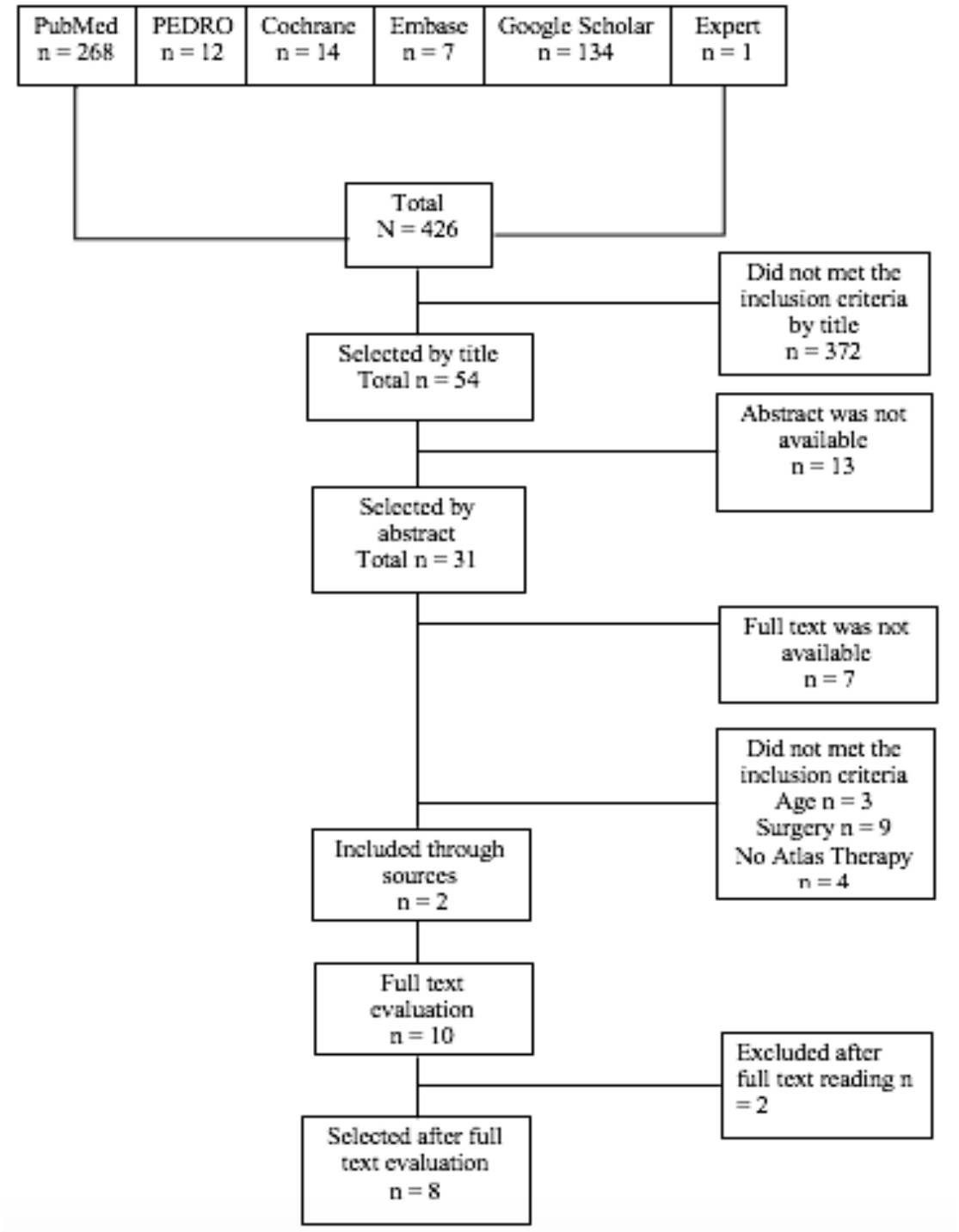


Figure 1 Flowchart: Article selection

Description of All Included studies

Study-design

Study forms, namely pilot studies, retrospective studies, cohort studies and case reports, were included in this review. The timeframe of the studies was not restricted, however, and it refers from 2002 to 2015. The publication language comprises English and German, while the studies were conducted in Switzerland, United Kingdom, Canada and United States of America (n = 5), respectively.

Quality Assessment

Newcastle-Ottawa Assessment Form

In both included cohort studies (Voigts, M. F. 2013; Lerro, A. 2010) poor quality resulted (see outcomes in table 1). An elaborate table about each item section is shown in appendix IV a).

PEDro Scale

Pilot studies and retrospective based studies (Woodfield III et al., 2015; Bakris et al., 2007; Palmer & Dickholtz, 2009) were evaluated with the use of the PEDro scale (see appendix IV b). These studies obtained a score between six to nine points out of ten, thereby suggesting a moderate to high quality > 6/10. The studies by Woodfield III et al., (2015) and Palmer and Dickholtz (2009) resulted in 6/10 points on the scale, whereas Bakris et al., (2007) resulted in the highest of these scores with 9/10 points.

Care Statement Scale

The care statement scale was designed for researcher writing a case report that includes accurate and useful items to guide them through the process, and not to evaluate a study after it has been conducted. Therefore, an evaluation sheet to measure the outcome measurement could not be found. This refers to a limitation in the quality assessment of case studies Elster E. L., (2004); Kessinger & Dickholtz, (2009) and Alcantara et al., (2002). As no additional scale to measure the quality of case study could be found, this care statement checklist was used to ascertain the quality, in evaluating the items. The three case studies Elster E.L. (2004); Kessinger & Moe (2015) and Alcantara et al. (2001) reached to an amount between 24 and 29 out of 30 points, which may imply a high quality. The case study Elster E.L. (2004) resulted in 26 points out of 30, Kessinger & Moe (2015) resulted in 24/30 point and the highest grade was evaluated by Alcantara et al., (2001) that reached an amount of 29 points out of 30 points. (see appendix IV c)).

Table 1: Quality assessment

Literature	Newcastle-Ottawa Form	PEDro Scale	Care Statement Scale
Voigts M.F. (2013)	Poor Quality		
Lerro A. (2010)	Poor Quality		
Woodfield III et al. (2015)		6/10	
Bakris et al. (2007)		9/10	
Palmer & Dickholtz, (2009)		6/10	
Elster E.L. (2004)			26/30
Kessinger & Moe, (2015)			24/30
Alcantara et al., (2001)			29/30

Patient characteristics

The sample size of all literature amounts N = 965, including one study with a placebo group consist of 25 participants (Bakris et al., 2007). If the total sample size is separated gender specific, it results in n = 575 women and n = 390 men.
It has been evaluated that the included literature comprises different symptoms, clinimetrics and pathologies. All following symptoms, such as neck-, back-, shoulder-, sleeping-, gastrointestinal-, hip-, knee-, elbow complaints, sleepiness, muscle tension, headache, dizziness, nervousness, tinnitus, low appetite, extreme lethargy, extreme erratic sleep cycle, manic episodes, vision problems and decreased hearing acuity, are contained in the aforementioned studies. Furthermore, clinimetrics were defined as leg length discrepancy, postural changes and modification in quality of life. Moreover, hypertension, depression, migraine, petit mal seizures and temporomandibular disorder (TMD) were defined as pathologies. Additionally, primary complaints were defined as most frequent reported symptoms and/or pathologies that were analysed in number of participants throughout all included literature. The cohort study conducted by Voigts, M. F. (2013) measured that n = 350 participants had a leg length discrepancy, which was measured with an inclinometer that resulted in an unlevelled iliac crest. The NUCCA approach measured the leg length via the supine leg check (SLC) on a total amount of 108 participants and the KCUCS method used a prone leg length check on one participant. Therefore, in the view of clinimetrics, a total number of n = 459 participants show a leg length discrepancy. A number of n = 441 participants stated that they suffered from headaches, n = 233 from migraine, a number of n = 198 participants suffered from tinnitus, and n = 202 participants suffered from blood pressure impairments. Secondary complaints (atlas laterality and rotation, neck-, back-, shoulder-, sleeping-, gastrointestinal-, hip-, knee-, elbow complaints, sleepiness, muscle tension, dizziness, nervousness, low appetite, extreme lethargy, extreme erratic sleep cycle, manic episodes, vision problems, decreased hearing acuity, postural changes, and modification in quality of life, depression, petit mal seizures and TMD) will be mentioned in

the result section, but special attention will be focused on the primary complaints. No clear statement can be given about the number of participants, experienced traumatic events before their atlas vertebra therapy, but it can be given that at least 52 participants suffer from a traumatic event.

Interventions and Comparisons

To sum up, a number of n = 350 participants received the AtlasPROfilax intervention, n = 504 the ATLANTOtec, the NUCCA intervention n = 83 (n = 108 with placebo group), IUCCA n = 1, KCUCS n = 1 and the Gonstead intervention n = 1. The intervention of AtlasPROfilax and ATLANTOtec, put their primary attention to decrease the surrounding muscle tension in order to realign the atlas vertebra. This procedure can be applied by physiotherapists, doctors, and osteopathic after special training/education. On the other hand, the chiropractic approaches (NUCCA, IUCCA, KCUCS and Gonstead) use certain manipulation methods to realign the atlas vertebra to its neutral position. The literature by Bakris and colleagues, (2007) is the only included study that inspect a control group in terms of the relationship between atlas vertebra realignment and the blood pressure in hypertensive patients. Within the control group the examiner pretended to give an identical atlas vertebra treatment. However, the patient's head was slightly displaced on the head support and the therapist misplaced the hands intentionally to not get in contact with the atlas vertebra.

Table 2: Included studies

	Study Design	**1) Symptoms 2) Clinimetrics 3) Pathology**	**1) Participants (n) 2) Gender F/M 3) Age**	**1) Intervention 2) Control**	**Atlas Position/ Measurement**	**Outcome Measurement**
Voigts, M.F. 2013	Cohort Study	1) NA 2) Iliac Crest Inclination 3) NA	1) n = 350 2) 225/125 3) 13-82 years	1) AtlasPROfilax	´Malrotation´	Inclinometer (Iliac crest level)
Lerro, A. 2010	Cohort Study	1) Neck-, back-, shoulder-, sleeping-, gastrointestinal-, hip-, knee-, elbow-, blood pressure complaints, sleepiness, muscle tension, headache, dizziness, nervousness, tinnitus and others 2) NA 3) depression, migraine,	1) n = 504 2) 297/207 3) 16-84 years	1) ATLANTOtec	´Atlas Malalignment´	Qualitative well-being: Pain, sleeping pattern, blood pressure, tinnitus, migraine, depression
Woodfield III et al., 2015	Pilot Study	1) Headache 2) NA 3) Migraine	1) n = 11 2) 8/3 3) 21-61 years	1) NUCCA 2) NA	´Atlas laterality´ and ´Atlas rotation´	SLC (leg length), VAS (Pain), MSQL, MIDAS =Migraine and QOL

Bakris et al., 2007	Pilot Study	1) NA 2) NA 3) Hypertension	1) n = 50 2) 25/50 3) 21-75 years	1) NUCCA (n=25) 2) Placebo (n=25)	´Atlas laterality´ and ´Atlas rotation´	Blood pressure
Palmer & Dickholtz, 2009	Retrospective practice base study	1) Headache 2) Posture, QOL 3) NA	1) n = 47 2) 29/18 3) 18-65 years	1) NUCCA 2) NA	Atlas laterality´	VAS (pain), posture, QOL, Iliac crest level, atlas laterality
Elster E.L., 2004	Case Study	1) Headaches, migraine, petit mal seizures, low appetite, extreme lethargy, extreme erratic sleep cycle, manic episodes 2) NA 3) NA	1) n = 1 2) 0/1 3) 17 years	1) IUCCA	´Atlas laterality´ and ´Atlas rotation´	Patients perception to headaches, migraine, petit mal seizures, low appetite, extreme lethargy, extreme erratic sleep cycle, manic episodes
Kessinger & Moe, 2015	Case Study	1) NA 2) NA 3) Hypertension	1) n=1 2) 0/1 3) 55 years	1) KCUCS	Atlas misalignment anterior and superior with right laterality	Blood Pressure
Alcantara et al., 2002	Case Report	1) Decreased hearing acuity, headaches, tinnitus 2) NA 3) TMD	1) n=1 2) 1/0 3) 41 years	1) Gonstead	´Atlas laterality´ and ´Atlas rotation´	Pain, TMD, headaches

NA = Not applicable; F/M= Female/ Male; SLC = Supine Leg Check; VAS = Visual Analogue Scale; MSQL = Migraine Specific Quality of Life; MIDAS = Migraine Disability Assessment Scale; QOL = Quality of Life; TMD = Temporomandibular Disorder

Outcome Measurements

At first, primary outcomes were summarized by its results, followed by the secondary outcomes. To obtain a superior structure table 4 displays the results from each intervention. Additional information about the treatment course of the case studies can be found in the appendix V.

Primary Outcomes

Headache

Of the ones included, the studies by (Lerro A., 2010; Woodfield III et al., 2015; Palmer & Dickholtz, 2009 and Elster E.L., 2004) stated headache in their frequency and/or intensity by the use of different outcome measurements. The cohort study Lerro A., 20110 measured the headache on a qualitative level in form of a questionnaire, using a seven-dimension scale for the pain intensity and frequency. This questionnaire is no standardized measurement tool, that is used in clinical practice. It was developed by ATLANTOtec itself and approved by a German research institution so-called Institut für Kundenzufriedenheits-Analysen und Marketing (INKAM). This cohort study reported that 78 % of the participants suffered from headache before the ATLANTOtec intervention and improved post-intervention to an amount of 66 % of participants of which 21 % stated to be asymptomatic. The case report by (Elster E.L., 2004) indicated the participants own interpretations, that reported a reduction of headaches after two weeks post-intervention, which gradually reduced after three months to two times per week and after four months to two times per month. A follow-up of 18 months indicated the patient to remain asymptomatic. The studies by Woodfield III et al., (2015) and Palmer & Dickholtz, (2009) applied the NUCCA approach and utilized the visual analogue scale (VAS) to evaluate the headache pain intensity in a tenth scale (see scale on appendix VI d), of which zero is no pain at all and ten refers to the worst pain scenario. The study by Woodfield III et al., (2015) resulted in significant pain reduction of - 0.044, 95 % Confidence Interval (- 0.055, - 0.0326), $p < 0.001$. The study by Palmer & Dickholtz (2009) evaluated the VAS scale on 35 participants from the first 150 days of treatment. Two weeks after the NUCCA intervention the pain intensity reduced to 36 %. The pain for the treatment group reduced to approximately 75 %, within 150 days post-intervention. Additionally, Woodfield III et al., (2015), analysed the effects of headache on patient´s, which are restricted in their everyday functionality, with the so-called Headache Impact Test-6 (HIT-6) see appendix VI h). This HIT-6 is a questionnaire that consists of six questions and helps to analyse patients limitations in every-day tasks (Quality Metric, Inc. and GlaxoSmithKline Group of Companies, 2001). Within the answers the patient has the option to choose between never, rarely, sometimes, very often and always. The minimum score amount 36 points and maximum score refer to 78 points, of which the evaluation sheet advises the patient to consult a doctor by 50 points, as this level might restrict the patient in their functionality. In the study the HIT-6 shows a significant improvement measured with mean of 64.2 (SD = 3.8) at baseline that improved to 53.8 (SD = 6.8) eight weeks after intervention resulting in a p of = 0.001. Furthermore, descriptive statistics for headache diary were included to calculate the headache days per month. The results showed that, one month after intervention headache have improved, from 14.5 (SD = 5.7) headache days per 28-day month at baseline to 8.7 (SD = 4.3) headache days per 28-days month, after eight weeks of intervention. However, this study shows no statistical significance with a p of 0.006.

Migraine

The studies by Lerro A., (2010); Woodfield III et al., (2015) and Alcantara et al., (2001) included participants with migraine. Lerro A., (2010) reported on the same qualitative questionnaire mentioned in the headache section. The results show that 44 % of participants stated to have migraine before the ATLANTOtec intervention, 39 % reported to be asymptomatic and 42 % reported improvement after the intervention. The case report by Alcantara et al., (2001) measured one participant that suffered in average of two migraine attacks per month before the Gonstead intervention. Information about the migraine progress within the time of care was not applicable, but one-year follow-up, stated that the patient remained asymptomatic in all symptoms. Woodfield III and colleagues (2015) analysed migraine-specific quality of life measurement (MSQL) before and after the NUCCA intervention. Jhingran et al., (1998) reported that MSQL is a 16-item Migraine specific quality of life questionnaire, developed by Glaxo Wellcome Inc. This questionnaire is of reason to assess the effect of migraine and its treatment on the patient's health in terms of quality of life and included three dimensions including Migraine-Specific Quality of Life Measure-Restrictive (MSQL-R), Migraine-Specific Quality of Life Measure-Emotional (MSQL-E), Migraine-Specific Quality of Life Measure-Physical (MSQL-P) (Jhingran et al., 1998). These assessment tools were evaluated at baseline, week-four and week-eight. The MSQL-R scored 38.4 (SD = 17.4) at baseline and improved to 69.1 (SD = 22.7) four weeks after NUCCA intervention and scored 73.5 (SD = 28.0) after eight weeks of treatment and resulted in $p < 0.001$. The MSQL-E scored 53.3 (SD = 23.5) at baseline and 82.4 (SD = 16.9) after four weeks and improved to 81.2 SD = 29.2) after eight weeks ($p < 0.001$). At lasts the MSQL-P scored 54.1 (SD = 18.1) at baseline, 83.2 (SD = 16.9) after four weeks and 86.8 (SD = 16.9) after two months post-intervention and shows significant improvement of $p < 0.001$. The Migraine Disability Assessment Scale (MIDAS) is a questionnaire designed to quantify headache-related disability in a period over three months (Stewart et al., 2000). This questionnaire shows a moderately high test-retest reliability in patients with migraine. The MIDAS was measured at baseline and week-twelve (week-eight after intervention) to indicate clinically significant change. The MIDAS mean scored 46.7 (SD = 27.7) at baseline. Eight weeks after NUCCA intervention the mean dropped to 32.1, 95% CI (13.2, 51.0), that results in a significant reduction of migraine disability ($p = 0.004$).

Tinnitus

In the study by Lerro A., (2010) an amount of 197 participants stated to suffer from tinnitus. On this previous mentioned qualitative questionnaire, resulted that 28 % stated to be asymptomatic after the ATLANTOtec intervention and 45 % of the participants experienced improvement of the tinnitus, whereas a distinction of frequency and/or intensity is not applicable. In the case study of Alcantara et al., (2001) the participant stated to be asymptomatic on the ninth visit after the Gonstead intervention from baseline. A follow-up of nine months reported the patient to have remained asymptomatic.

Blood Pressure

The cohort study by Lerro A., (2010), the pilot study by Bakris et al., (2007) and the case report by Kessinger & Moe (2015) evaluated the relationship between high blood pressure (BP) and the intervention of an atlas vertebra correction. The study by Lerro A., (2010) stated no clear results in regard to the BP level, as they used a qualitative questionnaire with a seven dimension to tick the intensity and frequency of certain complaints and/or pathologies like blood pressure. However, the results showed that 30 % of the participants had complaints with their blood pressure before the ANTLANTOtec intervention an amount of 29 % experienced an improvement and 25 % stated to experience no complaints at all. Information about the BP values cannot be retrieved. The pilot study by Bakris et al., (2007) included total amount of 50 participants of which 25 participants were in the treatment group (n = 10 female, n = 15 male). and n = 25 in the control group (n = 15 female, n = 35 male). All participants in the treatment group received the atlas realignment manipulation (NUCCA) and the placebo group received an intended atlas vertebrae correction in which the practitioner did not manipulate C1 at all. The mean systolic blood pressure value from baseline was 147 mmHg and reduced to 129.8mm Hg after eight weeks post-intervention that results in a decline of - 17±9 mmHg, versus the placebo group that had a systolic BP of 145.5 mmHg at baseline and reduced to 142.1mmHg after intervention that result in a decline of - 3±11 mmHg and together show a significant improvement of $p < 0.0001$. The diastolic BP decreased from baseline mean 92.5 mmHg and at week eight 82.2 mmHg (-10±11 mmHg) in comparison to the placebo group - 2±7 mmHg, that together resulted in P=0002. There was no significant reduction in heart rate - 0.3 bpm in the NUCCA group and a slight increase of 0.5 bpm in the placebo group. To sum up, an atlas realignment applied by the NUCCA approach, shows a sustained reduction in BP, similar to the effect of two-drug combination therapy used in hypertension patients. Furthermore, the case report by Kessinger & Moe (2015) involved a treatment duration of seven months, in which the patient visits the chiropractic 21 times. Within the course of care, one upper cervical adjustment was required through the KCUCS method. The blood pressure (BP) was measured before the upper cervical adjustment and amounted systolic 180 and 110 diastolic pressure measured in millimetre of mercury (mmHg). Moreover, 45 minutes after the atlas vertebra correction, the BP decreased to 164/94 mmHg. A gradual decrease of BP over the seven months was recorded (see appendix V c). After around six weeks, the patient reduced the BP medication metoprolol and hyzaar by half and after around four months the patient reduced the hyzaar medication to every three days. The medication metoprolol is a selective ß1 receptor blocker and hyzaar is a combination of two active ingredients (losartan hydrochlorothiazide), which commonly used to reduce high BP patients (Koren-MIchowitz et al., 2005). After four and a half months the patient discontinued all medications, by having a BP of 159/85 mmHg. The BP continued to gradually decrease over time and resulted in 136/82 mmHg after seven months of chiropractic care.

Leg length discrepancy

The study by Voigts M.F., (2013), reported pre-Intervention that all participants (n = 350) had a functional leg length discrepancy before the AtlasPROfilax intervention. This leg length discrepancy was measured with an iliac crest inclinometer seen in the appendix VI a). This inclinometer consists of a horizontal bar with two sliding arms that rest on the superior surfaces of the iliac crest. Voigts M.F., (2013) calculated from all participants, a number of 72

% presented a shorter left leg with left to right inclination of the iliac crest and 23 % had a shorter right left with right to left iliac crest inclination. After the intervention only 16 participants still had minor leg length discrepancy that amount over 90 % of all participants obtained a levelled iliac crest. The pilot study conducted by Woodfied III et al., (2015), performed the supine leg check (SLC) to measure the leg length difference. This test consists of the patient in a supine resting position. The heel positions are then compared to one another, while the patient turns his/her head to the left or right. The examiner observes the heel change. The heels that appear parallel to each other while turning the head, indicates no atlas misalignment, whereas uneven heels indicate an atlas misalignment. The results in this study before the NUCCA intervention show an irregular leg length measured by the mean of 0.73 inches and resulted in normalization of 0.00 inches after the intervention and shows significant results ($p < 0.001$). The NUCCA intervention in the study by (James Palmer, 2009) measured also the leg length by the use of the SLC. At baseline the differences measured in mean amounted 0.82±0.30 inches improved to 0.01±0.09 inches, that showed a significant difference in leg length by $p < 0.001$.

Secondary Outcomes

Atlas Laterality and Rotation

Table 3 displays the difference in atlas position measured in inches with the use of three X-Ray views (see views in appendix VI e)) at baseline and after the NUCCA intervention. To compare all three NUCCA interventions in terms of atlas laterality the study H. Charles Woodfied III et al., (2015) measured a mean of 3.25 (SD = 1.57) at baseline and reduced to a mean of 0.75 (SD = 1.18) post-intervention that shows significant improvement of $p < 0.001$. Palmer & Dickholtz, (2009) show significant changes from atlas laterality measured from baseline mean 1.79±1.10 to 0.22±0.35 and post-intervention 0.28±0.40, that show a result of $p < 0.001$, whereas Bakris et al., (2007) reported a change measured in mean from baseline 2.17±1.10 inches to 0.28±0.40 inches after the NUCCA intervention ($p = 0.788$) and shows no significant difference. Furthermore, atlas rotation position showed significant difference of $p < 0.001$ in the study of Woodfied III et al., (2015), with a mean of 3.00 at baseline, reduced to 0.00 post-intervention, whereas Bakris et al., (2007) the mean amounted 1.29±1.05 at bassline and reduced to 0.19±0.36 after NUCCA intervention that show a p-value of $p = 0.103$ as non-significant outcome measurement.

Table 3: Atlas Laterality and Atlas Rotation

Atlas Laterality	**Pre-Intervention Degrees (°) Mean* (SD)**	**Post- Intervention Mean* (SD)**	**P-Value**
Woodfield III et al., (2015)	3.68 3.25* (1.57)	1.32 0.75* (1.18)	$p < 0.001$
Bakris et al., (2007)	2.17±1.41*	0.22±0.35*	$p = 0.788$
Palmer & Dickholtz, (2009)	1.79±1.10*	0.28± 0.40*	$P < 0.001$
Atlas Rotation Source	**Pre-Intervention**	**Post-Intervention**	**P-Value**
Woodfield III et al., (2015)	2.57 3.00* (1.12)	0.57 0.00* (0.85)	$p < 0.001$
G. Bakris et al., (2007)	1.29±1.05*	0.19±0.36*	$p = 0.103$

Psychological symptoms

The case report of Elster E.L., (2004) applied the IUCCA method to one patient and reported a reduction in seizures, manic episodes and improved sleeping pattern in longer sleeping duration, within the first month post-intervention. Eight weeks post-intervention the seizures and mood disorder has been diagnosed as stable. No evident depression or anxiety has occurred since the atlas correction. After five to six months all symptoms were absent. A follow-up of 10 months the patient stated to remain asymptomatic. These factors were measured by the patient statements and the doctor, but specific measurement tools were not applicable (see progress in appendix V b)).

Temporomandibular disorder

Alcantara et al., (2001) applied the Gonstead technique on one single case with temporomandibular disorder (TMD). No specific measurement tool was used to assess the patient. After nine visits the patient stated to be asymptomatic. By the fifth visit the patient reported that the right ear was “perfectly fine” but a lot of talking have worsened the left TMJ and resulted in local pain and pain at the left periarticular region. Over the time the patient gradually improved with only the left ear sensation. A complete relief of TMD was perceived after two and a half months, from baseline. After nine months follow up the participant experiences no TMD symptoms (see progress in appendix V d).

Additional complaints

To sum up the cohort study by Lerro, A. 2010 included 18 different complaints, measured by a qualitative questionnaire using two seven domain ticker one designed for the intensity of complaints and the other for frequency. To generally sum up over 85 % of all participants, that received the ATLANTOtec intervention stated to be either asymptomatic or recognized a reduction in frequency or intensity of neck complaints and muscle tension. More than seven out of ten patients stated to be either asymptomatic or experienced a decrease in frequency and/or intensity in the following ailments, shoulder complaints, dizziness, back pain, sleepiness, hip complaints, sleeping disorder, tinnitus, depression and gastrointestinal complaints. Appendix V a displays the process of complaints and frequency from before and after the method.

Table 4: Summary of results from included studies, sorted by Intervention

Intervention	1) Symptoms 2) Clinimetrics 3) Pathologies	Articles & Results
AtlasPROfilax	1) NA 2) Leg length discrepancy 3) NA	(Voigts, M.F. 2013) ● 72 % shorter left leg with left to right iliac inclination ● 23 % shorter right leg with right to left iliac crest inclination ● Post-intervention only 16 participants had leg length discrepancy and over 90 % achieved a levelled iliac crest.
ATLANTOtec	1) Neck-, back-, shoulder-, sleeping-, gastrointestinal-, hip-, knee-, elbow-, blood pressure complaints, sleepiness, muscle tension, headache, dizziness, nervousness, tinnitus and others 2) NA 3) depression, migraine,	(Lerro, A. 2010) ● Post- intervention after one month 74 % of participants were in at least one complaint asymptomatic ● Most successfully treated complaint was migraine, with 39 % of participants being asymptomatic one month after intervention and 43 % stated alleviation in frequency and intensity ● 85 % reported to be asymptomatic or reduction in frequency and/or intensity of neck complaints, headache and muscle tension ● < 7 out of 10 participants reported to be either asymptomatic or reduction in frequency and/or intensity in shoulder complaints, dizziness, migraine, back pain, sleepiness, hip complaints, sleeping disorder, tinnitus, depression and gastrointestinal complaints
NUCCA	1) Headache 2) NA 3)Migraine	(Woodfield III et al., 2015) ● Atlas laterality resulted in significant difference from 3.96° at baseline to 1.32° after intervention ($p < 0.001$)

		● Atlas rotation resulted in significant difference from 2.57° at baseline to 0.57° after intervention ($p < 0.001$) ● Headache intensity has been improved from 14.5 headache days/28-day month at baseline to 8.7 headache days eight weeks after intervention ($p = 0.006$) ● Pain measured by VAS resulted in significant improvement eight weeks after intervention ($p < 0.001$) ● HIT-6 resulted in significant improvement in headache measured in mean from 64.2 points at baseline reduced to 53.8 points ($p < 0.001$) ● MSQL-R improved from 38.4 points at baseline to 73.5points eight weeks after intervention ($p < 0.001$) ● MSQL-E improved from 53.3 points at baseline to 81.2 points eight weeks after intervention ($p = 0.002$) ● MSQL-P improved from 54.1 points at baseline to 86.8 points eight weeks after intervention ($p < 0.001$) ● MIDAS improved from 46.7 points at baseline to 14.6 points after 3 months ($p = 0,004$)
	1) NA 2) NA 3) Hypertension	(Bakris et al., 2007) ● Significant improvement in systolic BP decrease from baseline 147 mmHg to 129.8 mmHg in -17±9mmHg in treatment group compared to placebo group 2±7 ($p < 0.0001$) ● Significant change in diastolic BP from 92.5 mmHg at bassline to 82.2 mmHg -10±11 mmHg in comparison to placebo group -2±7 mmHg ($p = 0.0002$) ● No significant change in heart rate in treatment and control group ● Atlas laterality resulted in 1.0 at baseline and 0.4° after eight weeks and placebo had 0.6 at baseline and reduced to 0.5° after eight weeks ($p = 0.002$ ● Effects are similar of two-drug combination therapy used in hypertensive patients
	1) Pain 2) Posture, QOL 3) NA	(Palmer & Dickholtz, 2009) ● LLI significant difference in leg length from 0.82±0.30 at baseline and 0.01±0.09 after intervention ($p < 0.001$) ● VAS significant reduction from mean 5.73±2.37 at baseline reduced to 1.26±1.48 after intervention ($p < 0.001$) ● SF-36 questionnaire all scores show statistically significant improvement post intervention 90-120 days (p value NA)
IUCCA	1) Headaches,	(Elster E.L., 2004)

	migraine, petit mal seizures, low appetite, extreme lethargy, extreme erratic sleep cycle, manic episodes 2) NA 3) NA	• Week 1, two C1 adjustments, no symptom reduction • Week 2 and 3, decreased headache and seizures, improved sleep and mood • Week 4, absence of mania and seizure, improved sleep, confirmed by neurologist • Week 5-8, one C1 adjustment, continued gradual improvement • Month 3 reduced headaches to 2x/week, sleeping 8-10 hours/night • Month 4, one C1 adjustment, reduced headaches to 2x/month, reduction in neck pain, improvements confirmed by neurologist • Month 5 and 6, one C1 adjustment, reductions in neck pain, normal sleep cycle • Month 7-9 absence of all symptoms • Month 10, one C1 adjustment, start working 40 hours per week • Month 12-18, three C1 adjustments, all symptoms remained absent
KCUCS	1) NA 2) NA 3) Hypertension	(Kessinger & Moe, 2015) • 21 chiropractic visits were required for a duration of seven month of care • BP at baseline systolic 180 mmHg and diastolic 110 mmHg • 45 minutes after KCUCS intervention BP decrease to 164/94 mmHg • After six weeks patient reduced medication metoprolol and hyzaar by half and after around four months the participant elected the hyzaar medication to every three days • After four and a half months all medications were discontinued with BP around 159/85 mmHg • Gradual decrease of BP continued to 136/82 mmHg after seven months
Gonstead	1) decreased hearing acuity, headaches 2) NA 3) TMD	(Alcantara et al., 2002) • At baseline the patient suffered from TMD with ear pain, tinnitus, vertigo, altered or decreased hearing acuity, sensation of pressure of fullness in both ears, 1-2 migraine attacks per month • 3rd visit the patient experienced greater improvement on the right side, than on the left • 5th visit the right ear was “perfectly fine” but a lot of talking worsen the TMJ and resulted in pain at left preauricular region • between the 6th- and 8th visit subsequent improvements with present left ear sensation • 9th visit the patient is complete asymptomatic of TMD • 1-year follow-up reported to remain asymptomatic

NA = not applicable; HIT-6 = Headache impact test-6; MSQL-R = Migraine-Specific Quality of Life Measure-Restrictive; MSQL-E = Migraine-Specific Quality of; Life Measure-Emotional; MSQL-P = Migraine-Specific Quality of Life Measure-Physical; VAS = Visual Analogue Scale; LLI = Leg Length Inequality; SF-36 = Short Form 36 Questionnaire; mmHg = millimetre of mercury; TMD = Temporomandibular disorder

Discussion

The original purpose of this literature review was to examine the effects of atlas vertebra correction in patients with an atlas misalignment, in physiotherapeutic context. However as almost no literature with regard to physiotherapeutic approaches was found, the attention shifted towards a multidisciplinary view. Special attention was paid to headache, migraine, tinnitus, high blood pressure and leg length discrepancy since these were the most frequently stated complaints. This is the first literature review, looking at the general effects on atlas vertebra correction in patients with an atlas misalignment. Before delving into deeper analysis, it is of utmost importance to mention that, due to the nature of most of the included studies in this review, there is an inconsistency in the reporting of the results. In some articles, a p-value is not reported, others just report in percentages, and others report a qualitative result of the patient's perspective. These heterogeneous outcomes needed caution by the evaluation and comparison of the findings. Therefore, it reported the actual data, and any inconsistency on the results is caused by limitations of the literature. Nonetheless, the pronounced lack of evidence made it impossible to draw a clear conclusion, however there is a trend towards positive results. Additionally, lack of accuracy about the specificity of each C1 intervention hinder the research to analyse and clarify the results. Each atlas vertebra intervention brings along different strengths and weaknesses. By combination of these one may be able to compensate for the one´s limitations with the other´s advantages. Different chiropractic intervention to realign the atlas vertebra exists. However, a comparison is hard, as the interventions show major differentiations from one another. The physiotherapeutic approach works more on the muscular structure by decreasing the tonus, whereas chiropractic approaches work directly on the atlas vertebra and manipulate it to its original position. A better understanding of the underlying mechanisms and the triggers of the symptoms, clinimetrics and pathologies would optimise the choice of intervention to offer the best suited treatment.

Three studies evaluated the effects on the NUCCA approach, of which the participants show different complaints. The study by Palmer & Dickholtz, (2009) showed significant improvements in the atlas position, body posture and decreased headaches within two weeks post-intervention. It is recognized that functional disorder in the apophyseal joints of the cervical spine play an important role in associated symptoms like headaches (Palmer & Dickholtz, 2009). This may indicate that treatment on the cervical spine can be beneficial to headache patient´s. The case study by Elster, E. L. (2004) applied IUCCA approach to realign the atlas vertebra. In this case study, symptoms like bipolar seizure, sleeping disorders, neck and back pain and migraine have been treated successfully after 12 months the patient remained asymptomatic for 18 months post-intervention. The fact, that the patients symptoms appeared after a traumatic fall on her head might influence the upper cervical spine in certain ways. Since no other treatment form, such from physicians, pain specialists, massage therapists and physical therapists had shown success. Therefore, the chance that the patient suffers from an atlas misalignment was perceived as high, since the atlas correction resulted in significant reduced symptoms. However, 12 months is a long period of which other factors could interfered to influence this outcome.

Furthermore, the study by Woodfield III et al., (2015) reported that the NUCCA intervention may be associated with a reduction in migraine frequency with improved quality of life. The study by Rocca et al., (2006) reported that defects in the descending circuits of the brainstem may contribute to migraine. Additionally, the case study by Elster, E. L. (2004) also reported that migraine can at least partially be attributed to malfunction of the brainstem and therefore affect nervous and circulatory structures. In the book by Göring, H. (2012),

Schümperli R. C. (1993) stated that a misaligned atlas vertebra creates pressure on the cranial nerves, which then can lead to an imbalance of the whole spine, in turn causing headaches, migraine, neck pain and leg length differences.
Moreover, the AtlasPROfilax method explains that a C1 malrotation can lead to a spinal dural torque, that causes an inequality of the sacral base and pelvic torsion. By correcting the atlas vertebra, the iliac crest level can automatically get back into its neutral position (Voigts, M. F. 2013). The cohort study by Voigts, M.F. (2013), measured that 350 participants had a leg length discrepancy pre-intervention, and resulted in the finding that over 90% of all participants obtained a levelled iliac crest post-intervention. This may be evidence for the argument that the iliac crest plane has an enormous influence on the atlas vertebra position or vice versa.

In addition, interesting results can be seen in the research of Bakris et al., (2007), which evaluated the relationship of BP and atlas vertebra realignment in hypertensive patients. This study conducted between-subjects design with a treatment and a control group, of which the control group experienced a pretended atlas correction therapy (placebo). Given that within the placebo group 36 % of stage one hypertension patients received a greater drop than 8 mmHg in their BP, compared to the treatment group that experienced a drop of 8 mmHg or higher in 88 %, which might indicate, that the brain influences our belief and can therefore influence the BP. This shows that a placebo effect may have an influence on the individual's well-being. A systematic review of Hall et al., (2010) resulted in the finding that the relationship between a therapist and patient can already have a positive effect on the treatment outcome in physical rehabilitation settings. This indicates, that the patient-physiotherapist relationship may influence clinical outcomes and can therefore distort the results. The case study by Kessinger & Moe, (2015) realised a normalization of blood pressure within seven months of treatment via the KCUCS methods. A reduction from 180/110 mmHg to 136/82 mmHg was found. As previously mentioned, the atlas vertebra position can restrict the brainstem function and therefore affects the blood pressure. It is well known that neurotransmitters in the medulla oblongata of the brainstem control the blood pressure level (Howe, P. R. 1985). The fact, that C1 is located very close to the brainstem, implies that any shift of the vertebra, might influence the brainstem in its functionality (Bakris et al., 2007).

According to Alcantara et al., (2002), the study evaluated the relationship between atlas vertebra misalignment and temporomandibular disorder (TMD). TMD brings along certain symptoms with it including tinnitus. The treatment according to the Gonstead procedure resulted to be successfully after two and a half months. Within this time, the patient visited the chiropractic nine times and remained asymptomatic nine-month post-intervention. According to Walczyńska-Dragon et al., (2014), there is a significant association between TMD treatment and cervical spine. This might be a reason, why the atlas vertebra correction in the case study by Alcantara et al., (2002) has been successful. Furthermore, the study by Lerro A., (2010) an amount of 197 participants stated to suffer from tinnitus. The book by Langguth et al., (2007) stated that tinnitus is associated with the craniocervical junction and is most frequently seen in temporomandibular joint syndrome. Therefore, any alterations within the cervical spine may be associated to preserve any form of tinnitus.

Study design

This literature review included a total amount of eight studies that comprise of the level of evidence from 2B to 4, of which 2B includes individual cohort studies 2C ecological studies, 3A systematic reviews of case-control studies, 3B Individual case control studies

and 4 includes case series according to the centre for Evidence-Based Medicine mentioned in the study by Patricia et al., (2012). Due to the fact that systematic reviews of randomised controlled trials (RCT´s) level 1A and individual RCT´s were not included in this review, lowers the level of evidence dramatically which, might lead to an increased risk of bias. Working on a such diverse spectrum of evidence levels, can aggravate the outcome measurements. The cohort study by Lerro, A. (2010) was received from an atlas vertebra therapist, which is not published on the databases, points out that the lack of evidence is drastic. The fact that this study created a self-constructed qualitative questionnaire that is neither measured on its reliability nor on its validity might distort the results dramatically. Due to the fact, that the review was performed by a single bachelor student, it is possible that possibly data was missing in this review. It should be taken into consideration that the selected studies cover the languages English and German, which might influence the researches perception of information that in turn can lead to slightly modified interpretations. The fact, that studies including children, fractures or surgeries were excluded in this research, restricted the amount of evaluated data. An ensuing research would be expedient to receive more information. By virtue of little number of published articles on C1 correction in physiotherapy, a general incongruity of research design is present and cannot be corrected for by the researcher. However, this current lack of research might be helped by future studies focusing on the various effects of atlas vertebra therapy, perhaps in an interdisciplinary approach.

Relevance

The following describes an unpublished paper that resemble the ATLANTOtec procedure. This physiotherapeutic survey was preserved by the employer (Stefan Datt) of the researcher and was evaluated between the years 2015 to 2017. A number of 58 participants were included and stated that 62 % (n = 36) experienced improvements, 17 % (n = 10) had minor improvements and 21 % (n = 12) did not experienced any change. In the case of 15 % (n = 9), the complaints have been absent completely, 40% (n = 23) experiences complaints very rarely, 21 % (n = 12) reduced the symptoms to once a month reduced the symptoms to > 1 / week 14 % (n = 8) or had no change of their complaints 10% (n = 6). There is no data weather the patient experienced deterioration after the intervention, as no question was posed on that. A number of 86 % (n = 50) would further recommend the atlas correction therapy, 8 % (n = 5) would not recommend this therapy and the other 6 % (n = 3) did not give any information. The main complaints were pain at the cervical spine region, back pain, migraine, tinnitus, dizziness, lower back pain and iliosacral joint complaints. This study has not been published, but the information has been obtained at the internship place and the author agreed to mention the results.

By looking at the intervention of AtlasPROfilax and ATLANTOtec the results showed beneficial outcomes in regard to different symptoms, clinimetrics and pathologies. This atlas vertebra correction can be applied by physiotherapists after a special atlas vertebra education/training. The main emphasis was set to decrease the muscle tension, which then leads to a self-adaptive realignment of the atlas vertebra. Nonetheless, muscle relaxation is commonly applied by physiotherapists through different therapies. Thus, it would be interesting to see whether an atlas vertebra correction would receive better results compared to regularly applied manual therapies in physiotherapeutic departments. According to Mulligan, “sustained natural apophyseal glides” (SNAG´s) and mobilization by movements (MWM´s) are interesting concept that should be taken into consideration as a possible approach to bring the vertebrae back to its natural bio-mechanical joint movements.

However, the lack of literature did not allow to include such therapy methods in this review. To sum up, in general special attention is paid to the cervical spine between C2 to C7 and thus does not include the C1. The study by Snodgrass et al., 2010 reported cervical spine mobilization on 120 patients with mechanical neck pain, and therefore applied posterior-anterior mobilization of grade I to IV on the vertebrae between to C2 and C7. Hence, judge the attention towards on the first cervical vertebra might broaden the view on cervical spine mobilization.

Notes of the author

The atlas vertebra correction is being applied in diverse physiotherapeutic facilities since several years but finding evidence appears to be hard. In the assessor's opinion, joint manipulation is accompanied with different risk factors and thus should be applied with caution. Therefore, previous mentioned apophyseal joint glides like SNAG´s and/or mobilisation with movement (MWM) according to Mulligan would be a possible approach to guide the vertebrae in its position. These therapies, seems to be a more sensitive approach compared to a sudden thrust on the joints. However, these techniques could not be included in this study, as no appropriate literature could be found (Ecelby, L. 2002). In summary, it is required to apply further research to deepen the knowledge and to find reliable scientific information on the efficacy of promised effects. It is noteworthy that since the assessor has only little research experience, one might have a higher risk of bias compared to an experienced researcher.

Implications for physiotherapy practice

Nowadays, an increasing number of people suffer from headache, migraine, tinnitus and high blood pressure. These complaints might be reason of an atlas vertebra misalignment. Additionally, the social and psychological factors should to be taken into considerations, as these might also influence certain results. It is commonly known that stress can be a contributor to headache, migraine, tinnitus and high blood pressure. The results of this review can be used in the context of physiotherapy but also in the context of other therapeutic professions, such as chiropractors and atlas vertebra therapist. If further research will be available, this review can be used as a guideline for physiotherapists and chiropractors to receive some information on different interventions and its effects.

Conclusion

Despite highly diversity of interventions the present review found convergent results. It can be suggested that an atlas vertebra correction may be associated with reduction in headache, migraine, tinnitus, improved blood pressure levels and levelled leg length. However, this statement is based on studies with low evidence levels. Due to the high heterogeneity of parameters the clinical relevance of this conclusion is decreased. When talking about atlas vertebra correction in a physiotherapeutic context, a superior lack of evidence was found. Therefore, further scientific literature is required to evaluate the effects on atlas vertebra correction in physiotherapeutic departments. In future research, results of physiotherapeutic and chiropractic interventions should be analysed separately in terms of

symptoms, clinimetrics and pathologies. The approaches differ from each other too extremely to allow to draw clear conclusions. Additionally, future research on the underlying mechanisms of atlas vertebra subluxation and its therapeutic effects should make use of true experiments with control groups in order to allow causal conclusions.